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MEMORANDUM FOR PR (Contractor/In-House Publication)

FROM: PROI (TI) (STINFO) 24 Apr 2000

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-TP-2000-086**
I. Ismail (ERC), T. Hawkins, "Adiabatic Compression Sensitivity of Liquid Fuels and Monopropellants "

46th International Instrumentation Symposium **(Statement A)**
(Bellevue, WA, 30 Apr-04 May 2000) **(Submission Deadline: 24 Apr 2000)**

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Adiabatic Compression Sensitivity of Liquid Fuels and Monopropellants

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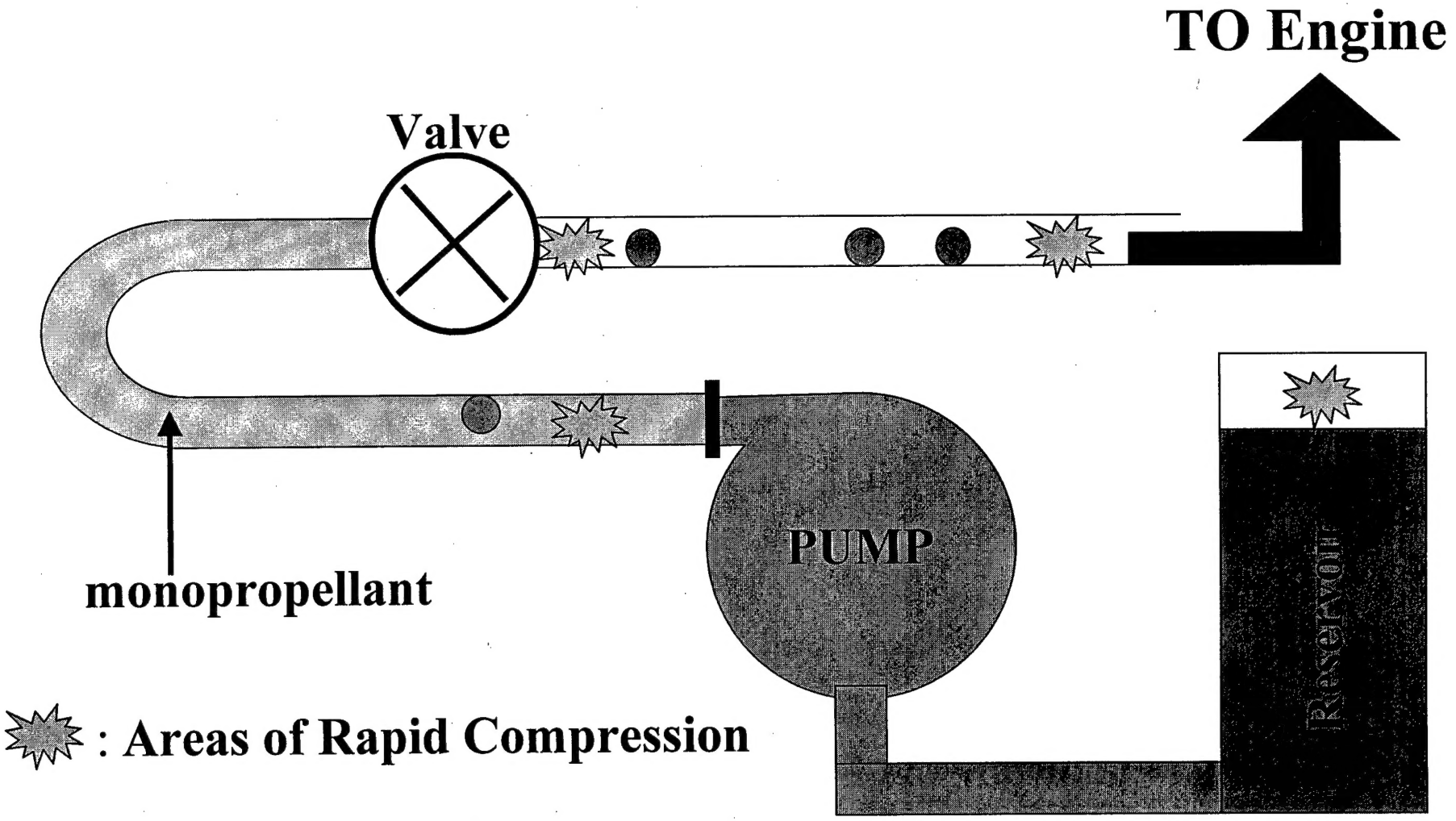
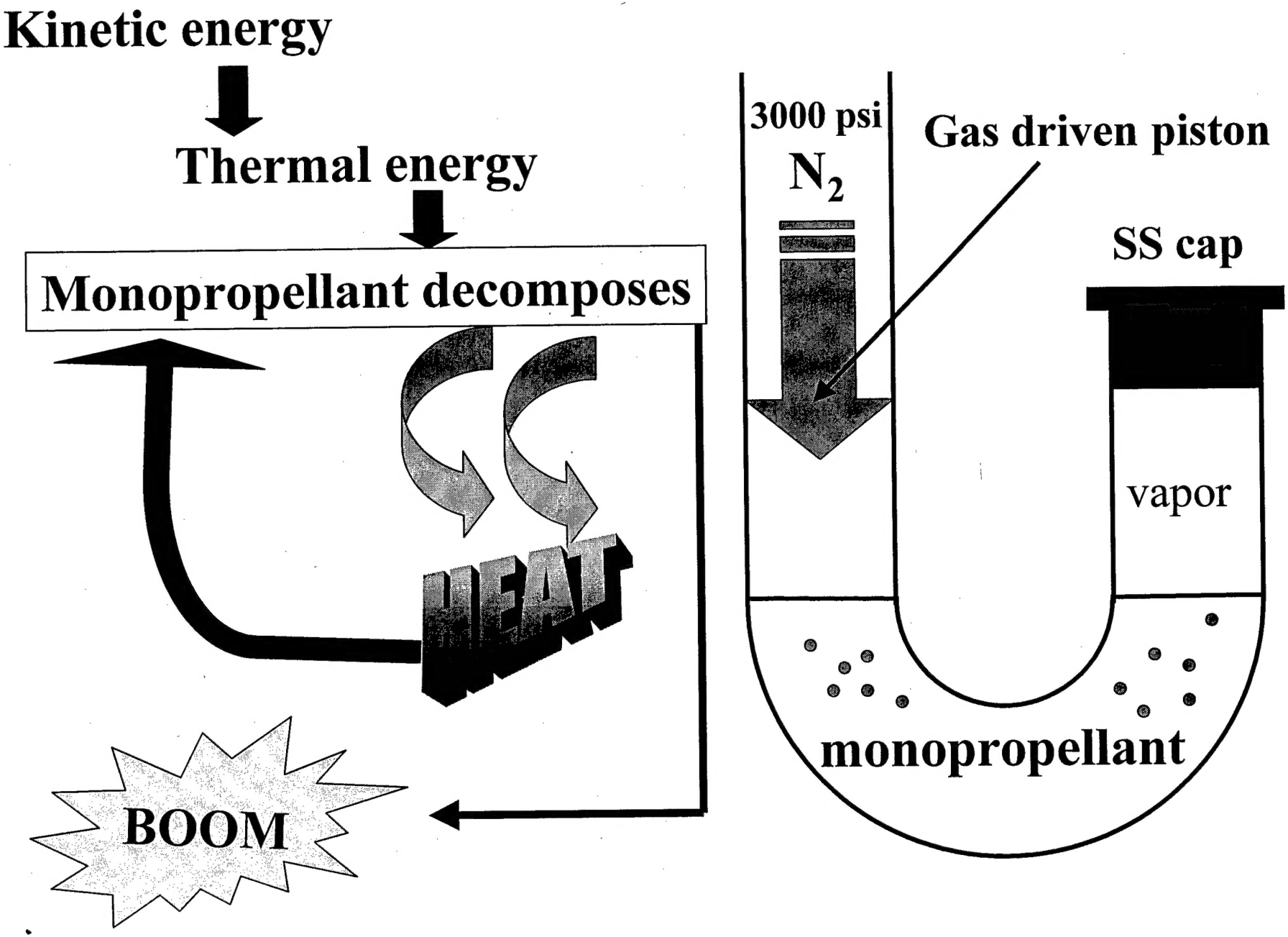
CONCERN

Rapid compression results from mechanical shocks to reservoir, from rapid opening/closing of valves and from engine combustion instability.



CONCEPT of Adiabatic Compression



BACKGROUND

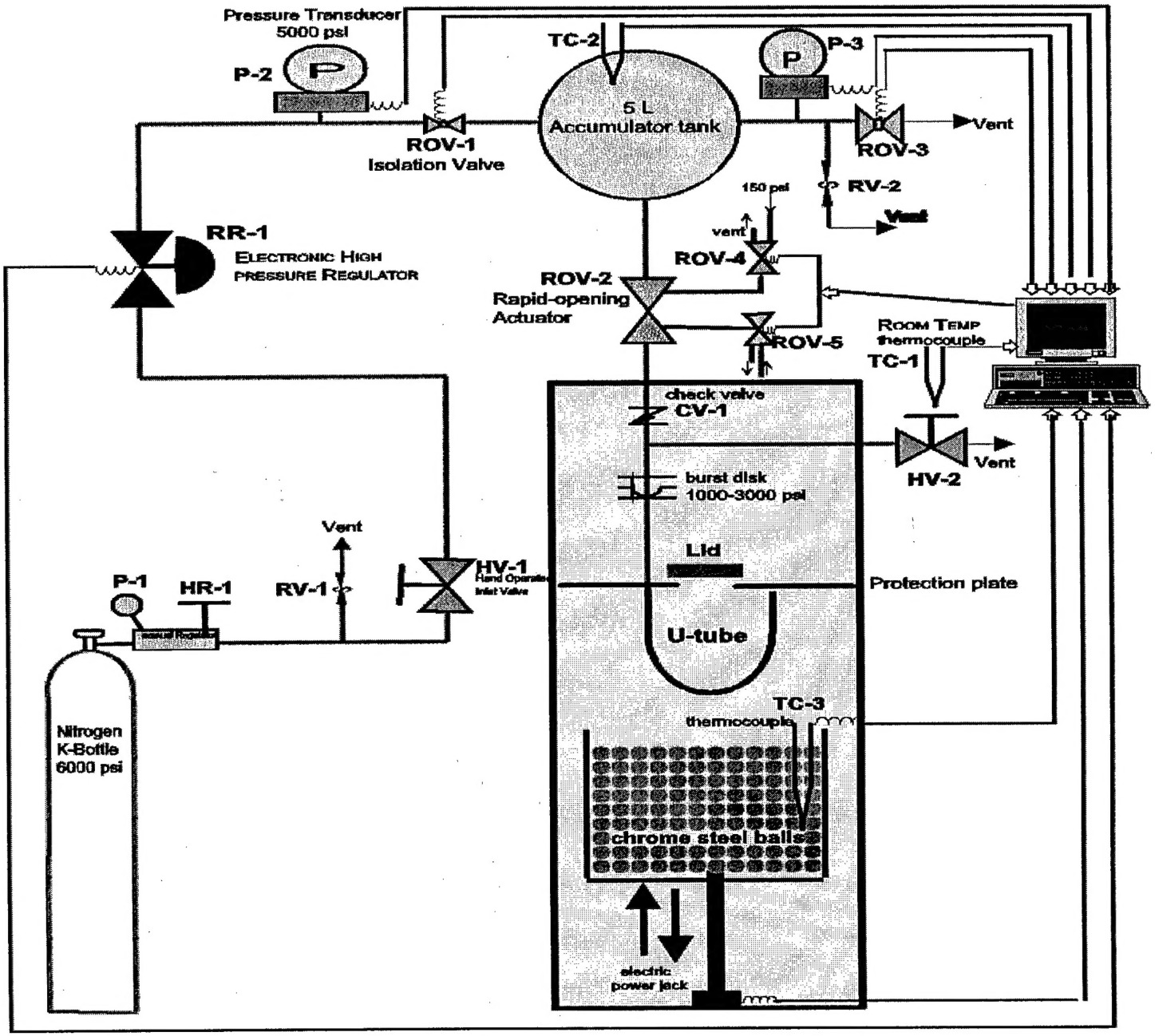
- Aerojet (1971-1980) tested adiabatic compressibility of hydrazine and propellants using 316-SS, 304L-SS and other alloys.
- They tested at two compression ratios: 32:1 and 79:1.
- They found that the threshold temperature for different liquids was 90 -100 ^{o}C.
- NASA Report (1978): No standard procedure has been published.
- Hazards Research Corporation/Sundstrand Aviation (1975) have selected conservatively two test conditions for shuttle Operations:

	Initial Start Conditions	Restart Conditions
Compression rate:	25,000 psi/s	50,000 psi/s
Compression ratio:	30:1	20:1
Test Temperature:	27 ^{o}C	135 ^{o}C
Gas Bubble:	Air/hydrazine	Nitrogen/hydrazine

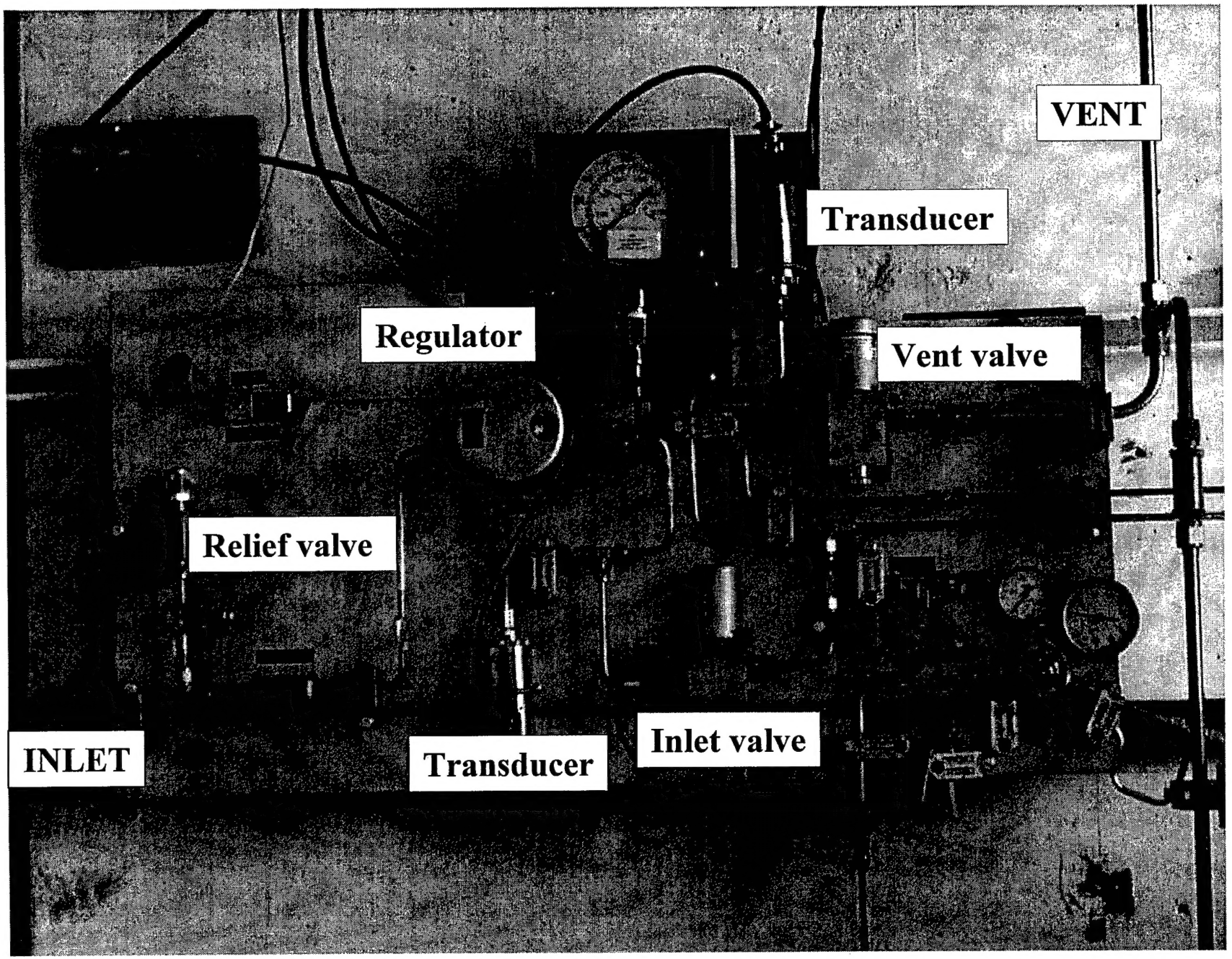
OBJECTIVES

- AFRL Required In-House capability to support new propellant development.
- Construct Adiabatic Compressibility System.
- Interface with computer (select A/D boards, I/O boards and low mV boards for thermocouples).
- Computer Program the system (using Labtech NoteBook).
- Three modes of operation:
    - Valve calibration mode
    - Actual adiabatic test mode for actual testing
    - Continuous saving mode for regular maintenance
- Fulfill safety and environmental requirements.

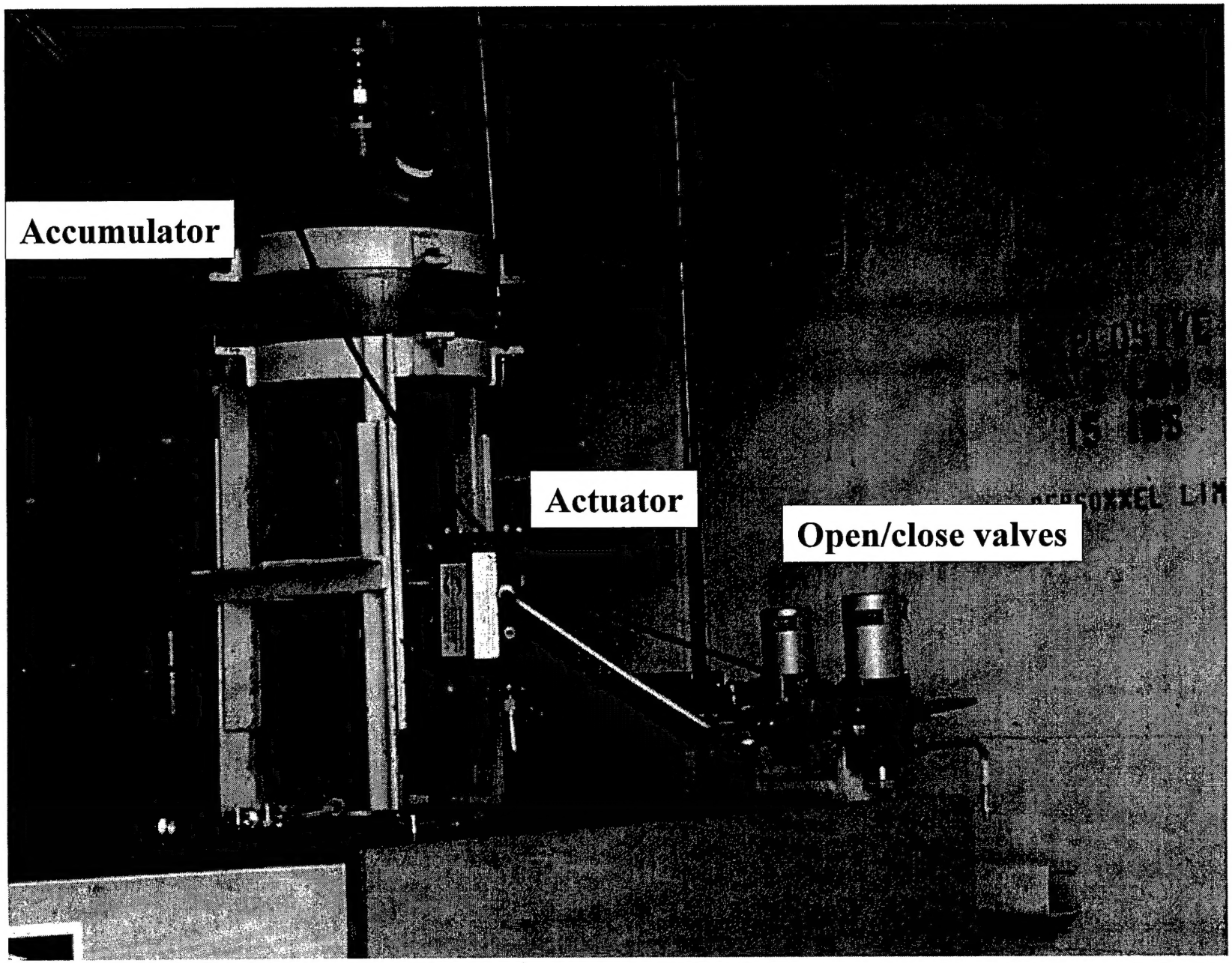
Adiabatic Apparatus



Manifold and Pressurization System



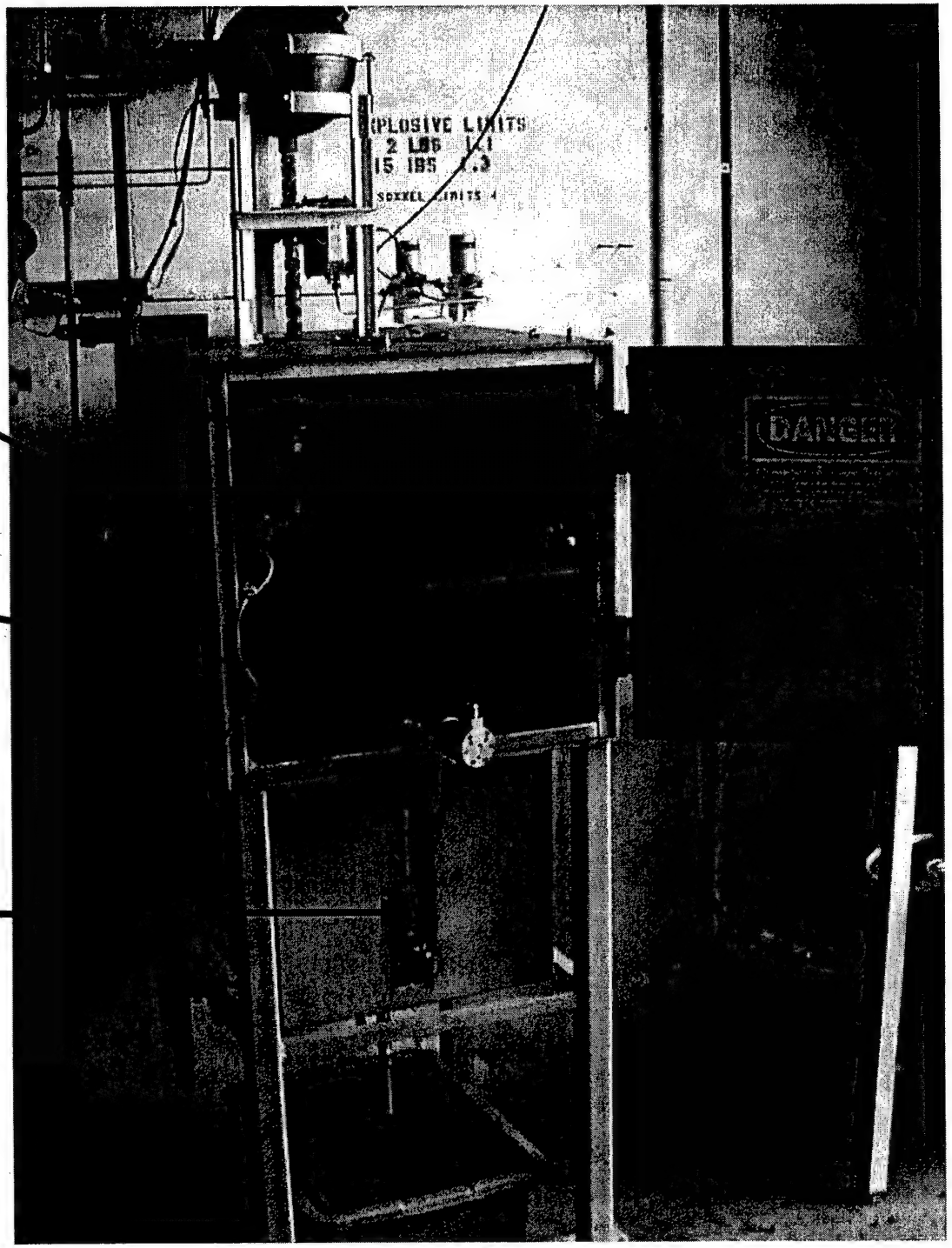
Accumulator and Fast Acting Valve



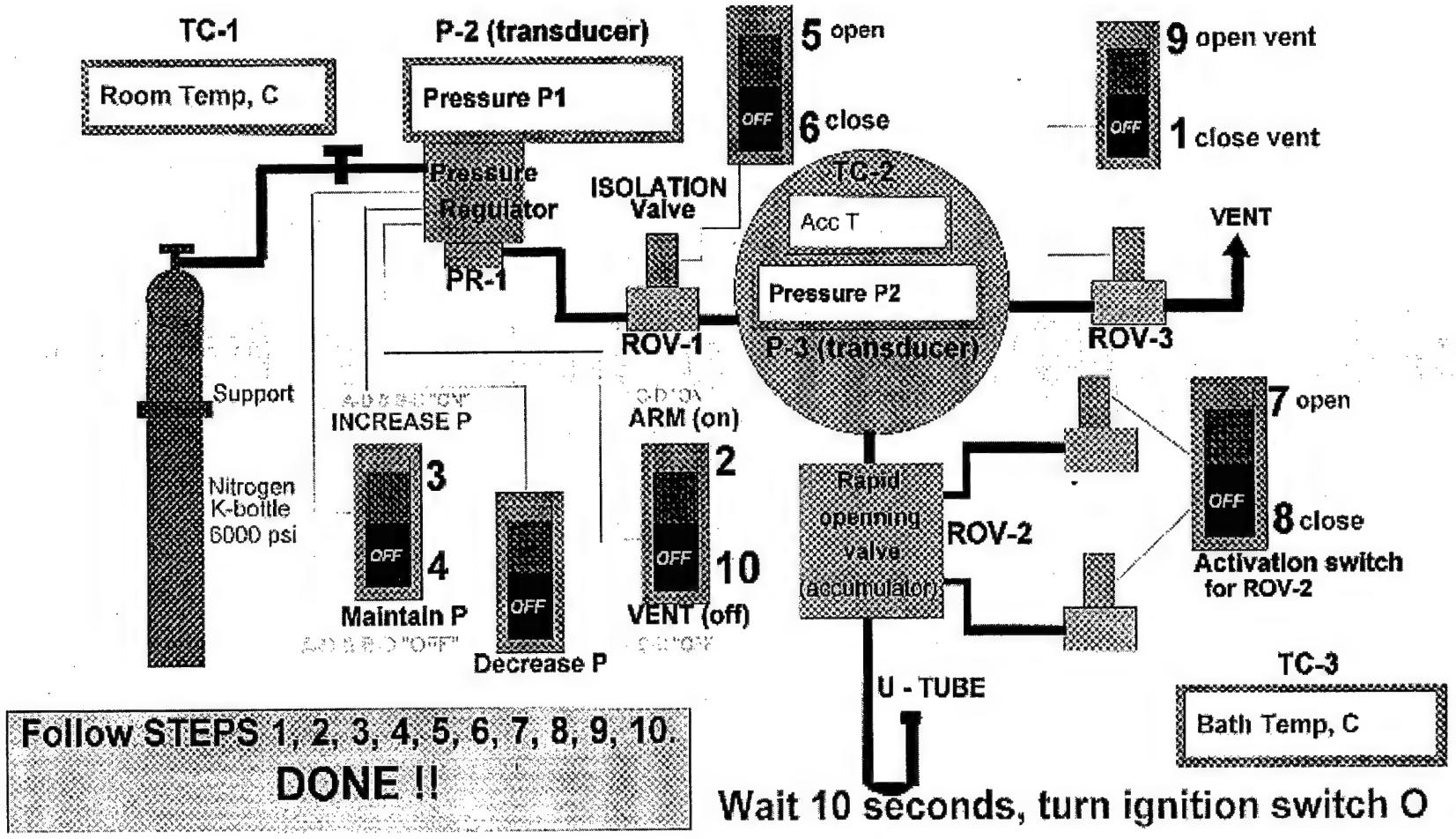
Compression Chamber

Location of Heating Bath

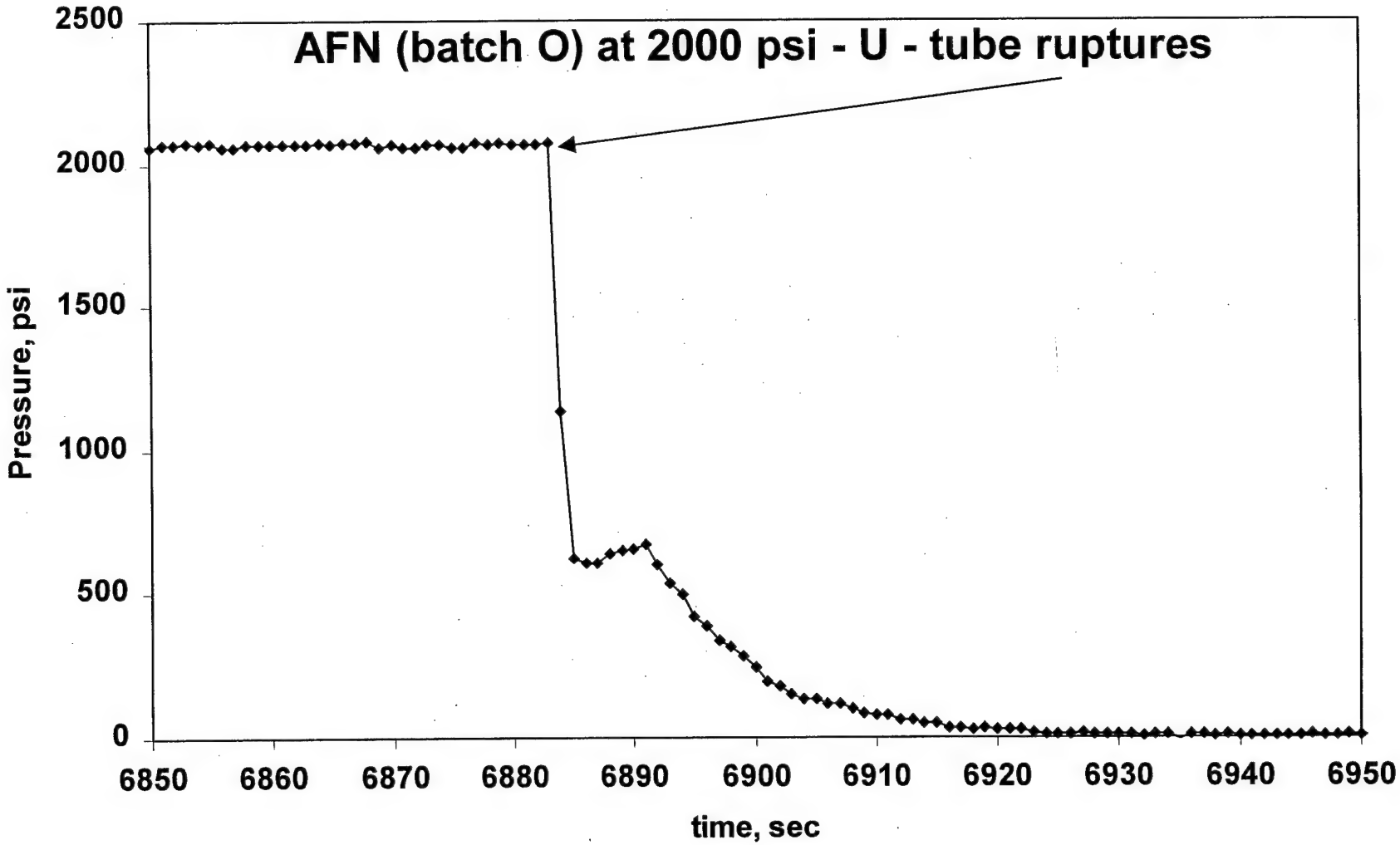
1-ton Jack (for raising and lowering heating bath)



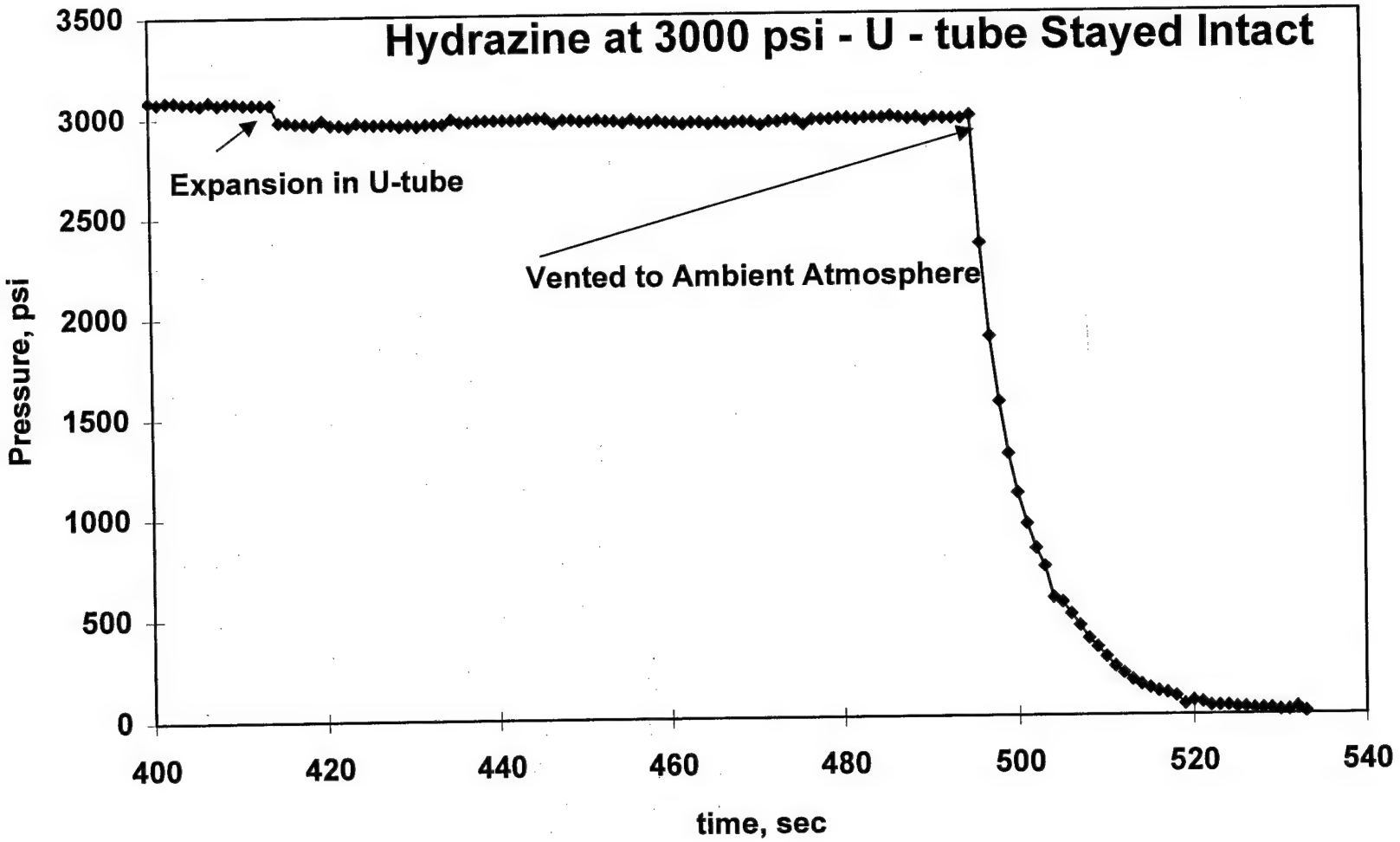
Computer Screen for LABTECH NoteBook Operating Program



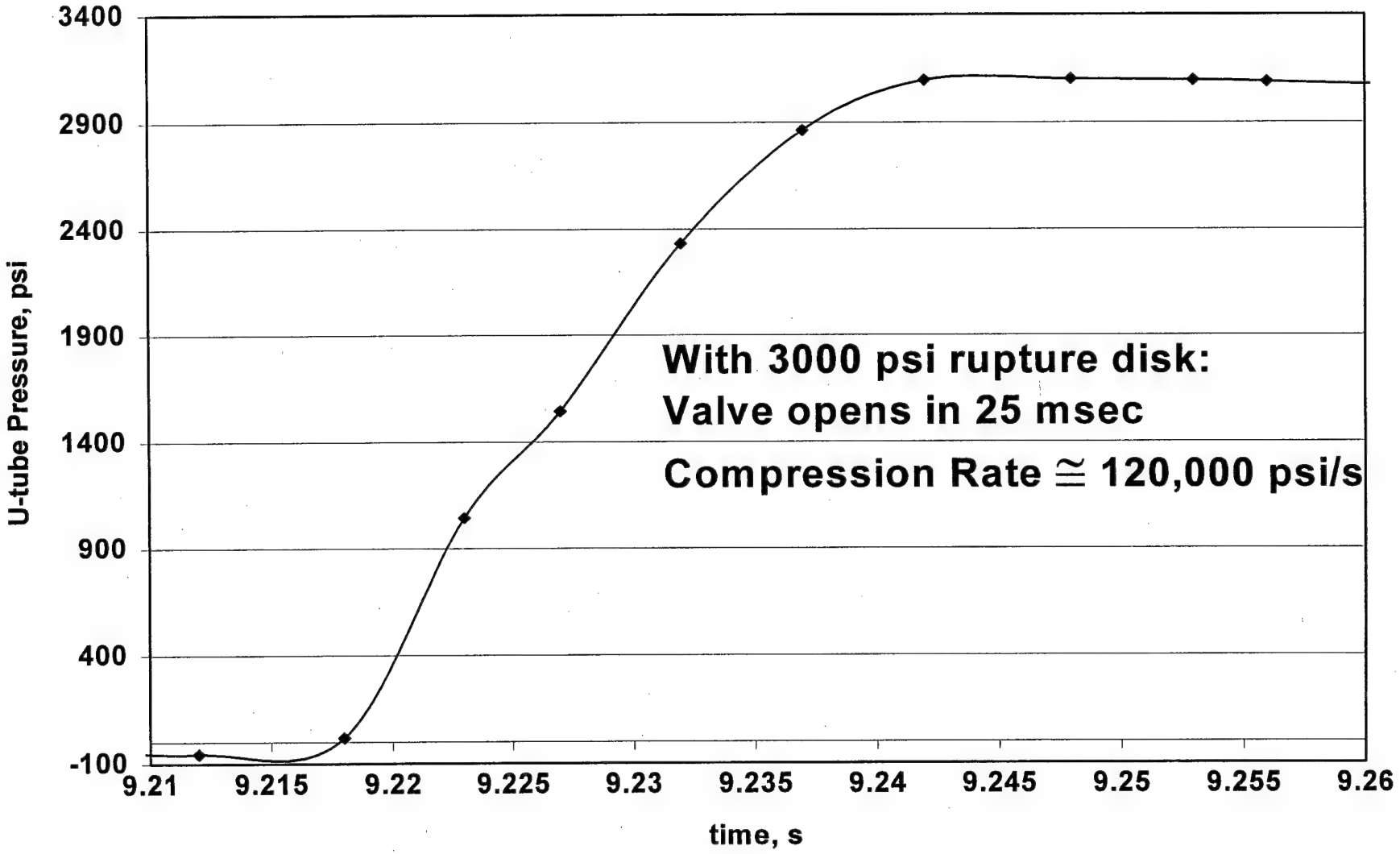
Typical Example of a Positive Test



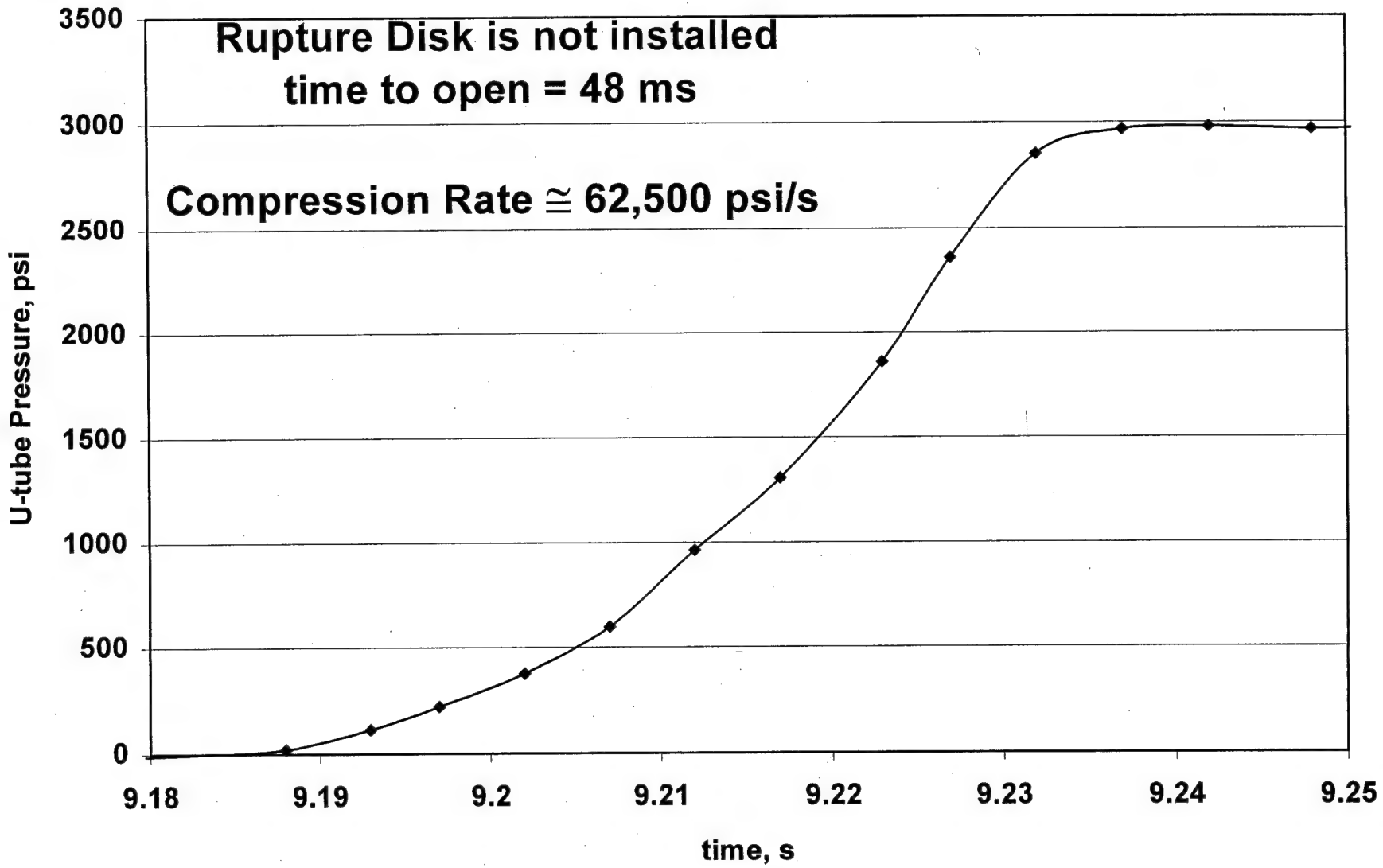
Typical Example of a Negative Test



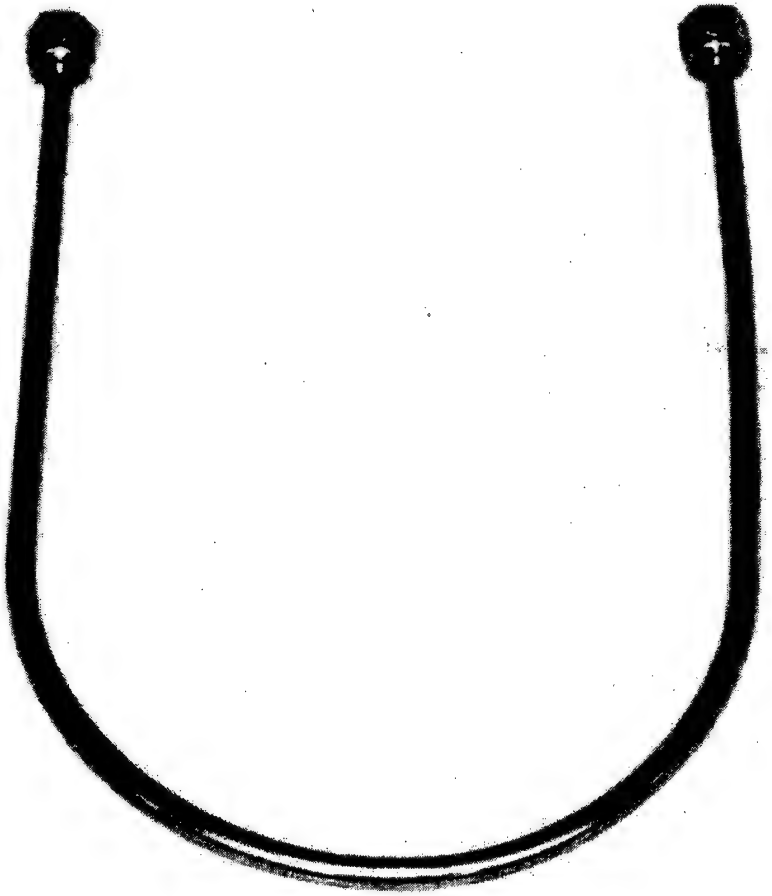
Compression Rate in Presence of Rupture Disk



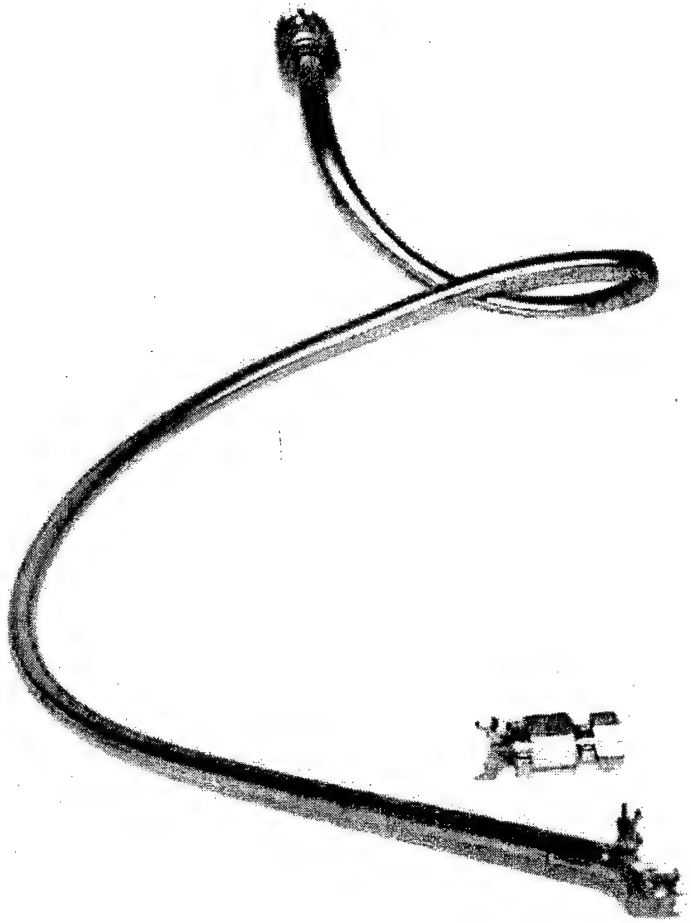
Compression Rate in Absence of Rupture Disk



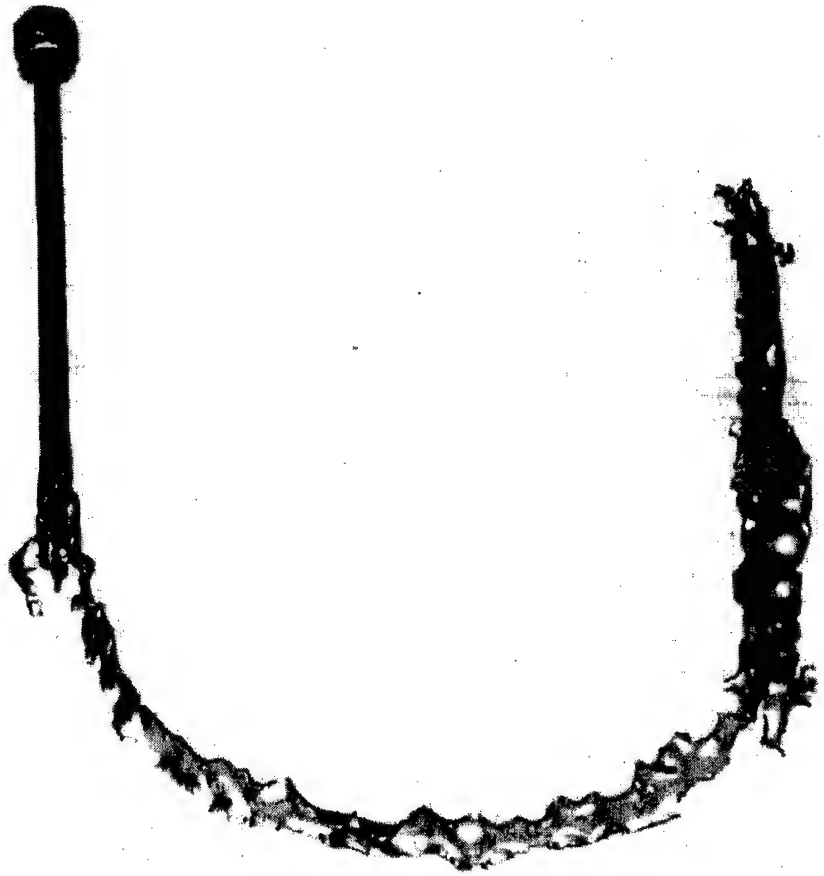
New tube or after negative test



Ruptured tube in a water bath



Severely damaged tubes in SS-ball bath



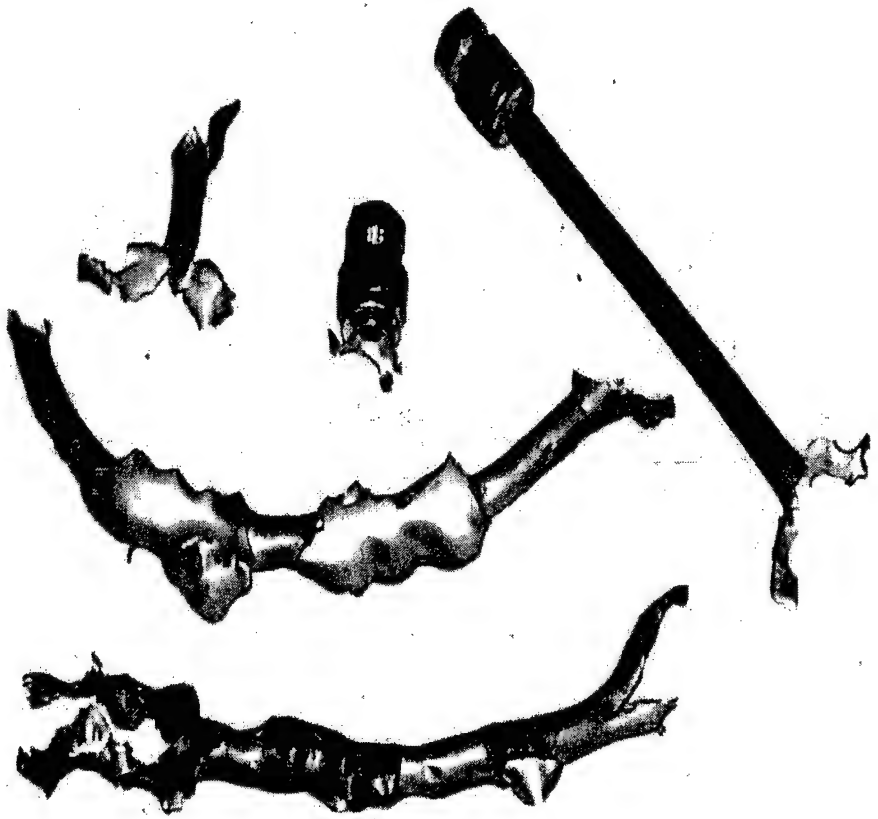


Table 1: Summary of Adiabatic Compression Results on Different Liquids

Test ID #	Sample	Temperature, °C	Pressure, MPa (psi)	Result
1	Hydrazine	70	20.684 (3000)	-
2	n-propyl nitrate	70	20.684 (3000)	-
3	Nitromethane	70	20.684 (3000)	+
4	AFN (Batch 21)	50	20.684 (3000)	+
5	AFN (Batch 21)	25	20.684 (3000)	-

Table 2: Summary of Adiabatic Results Obtained on AFRL monopropellants

Test ID#	Sample	Temperature, °C	Pressure, MPa (psi)	Result
1	RK618A	15	13.79 (2000)	+
2	RK618A	15	6.895 (1000)	+
3	RK618A	15	3.448 (500)	-
4	RK-100	100	20.684 (3000)	-
5	RK-315E	15	13.79 (2000)	+
6	RK-315E	15	6.895 (1000)	+
7	RK-315E	15	3.448 (500)	-
8	RK-315-A	15	20.684 (3000)	+
9	RK-315-A	15	13.79 (2000)	+
10	RK-315-A	15	6.895 (1000)	-

SUMMARY AND CONCLUSIONS

- A sturdy adiabatic compression apparatus has been constructed and successfully interfaced with a PC computer.
- A safe operating procedure has been established. Samples can be tested at temperatures up to 145 °C and at pressures up to 20.684 MPa (3000 psi).
- Typical rate of compressing rocket propellants is 120,000 psi/s. Maximum compression rate is 150,000 psi/s.
- Hydrazine is relatively stable to adiabatic compression when compared to other energetic liquids.
- All three propellants developed at AFRL passed the compressibility tests at a driving pressure ratio of 35/1.

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